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Monthly Performance Report

DALLAS RECREATION CENTER

MAY 1979

FEB 14 1980

U.S. Department of Energy

National Solar Heating and
Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT
DALLAS RECREATION CENTER
MAY 1979

I. SYSTEM DESCRIPTION

This solar energy system is installed in the North Hampton Park Recreation and Health Center in Dallas, Texas. The building contains an area of 16,000 square feet, which provides room for an 8,000-square foot gymnasium, a locker room and a health care clinic. The solar system is designed to provide 80 percent of the annual space heating, 48 percent of the annual space cooling, and 90 percent of domestic hot water requirements.

The solar energy system contains 238 single-glazed flat-plate collectors, manufactured by Honeywell, Inc., providing a gross area of 3,650 square feet. The collectors are mounted in 29 arrays on the roof of the building and face south. The collectors are tilted at an angle of 25 degrees from the horizontal. The heat transfer medium is an aqueous solution of 35 percent ethylene glycol. The capacity of the collector loop is 475 gallons.

Space heating is accomplished by the transfer of thermal heat, using heat exchangers, to the air handling system. Space heating is supplemented by a gas-fired boiler. The thermal energy is stored in a 6,000-gallon hot water storage tank which is located above ground in the mechanical room and is insulated with four inches of urethane.

Space cooling is supplied by using solar energy to operate an ARKLA absorption chiller. Chilled water is stored in a 2,000-gallon tank located above ground in the mechanical room and insulated with four inches of urethane. Auxiliary space cooling is provided by two vapor compression units.

Supply water (city) is preheated by heat exchanger HX3 on the hot side of the absorption chiller condenser loop. Preheated water is further heated by heat exchanger HX2, between the hot water storage and the domestic hot water heater (DHW heater). A conventional 100-gallon natural gas water heater provides additional thermal energy to satisfy the load requirement. The system, shown schematically in Figure 1, has five modes of solar operation.

Mode 1 - Collector-to-Storage: This mode is entered when either of two collector absorber plate thermal switches close and activate pump P1 at 180°F for cooling and 120°F for heating, respectively. The set points are automatically selected by manual demand switches on the control panel. Additionally, when the solution temperature leaving the collector system exceeds the hot water storage temperature by 20 degrees, pump P2 is energized. This mode continues until the temperature difference is less than three degrees.

Mode 2 - Space Heating: This mode is entered when the HEAT AUTO switch on the console switch panel is in the ON position. Pumps P4 and P5 are energized when valves V3, V6 and V7 on their respective hot water coils begin to open to the coil. At the same time, the control cycle for valves V4 and V5 will be enabled. The signal from an electronic sensor downstream of valve V4, reset by an outdoor electronic sensor, causes valve V5 to be positioned to maintain heating water at a selected temperature. The selected temperature is reset inversely to changes in outdoor temperature.

If the solar heated water temperature becomes too low to supply the heating demand, valve V5 reaches the full open position to storage, a time delay circuit is initiated, valve V5 closes to the storage tank, and valve V4 opens so that hot water from the gas-fired boiler may be used to satisfy the heating loads. The control cycle for valves V4 and V5 has a time delay which is adjustable up to a maximum of five hours. The time delay is to prevent valve oscillations. If, during this cycle, heating requirements are satisfied and valve V4 reaches the fully closed position to the boiler position, another time delay cycle is initiated which will cancel the previous time delay cycle and restore space heating to valve V5 and the solar energy source.

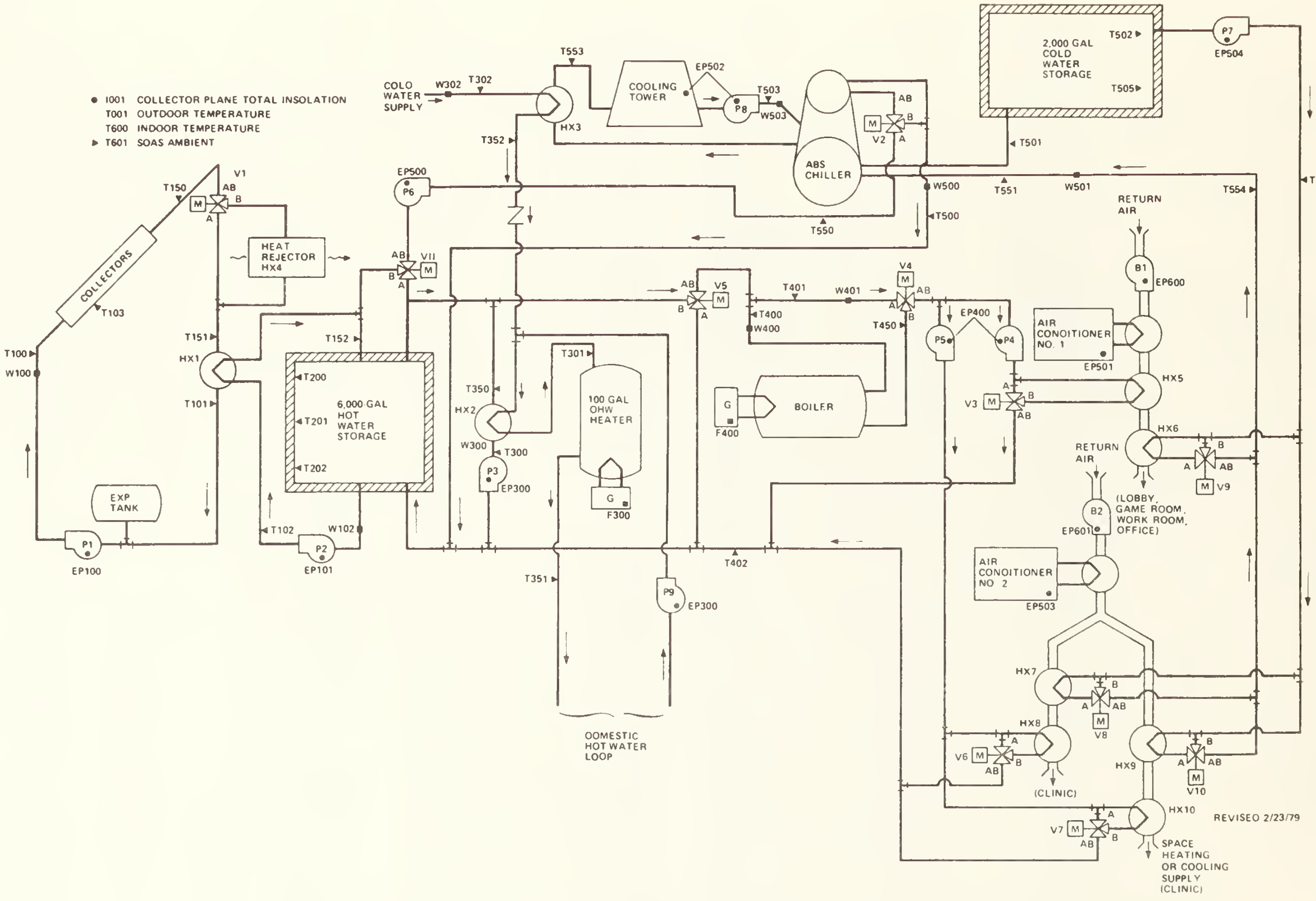

Figure 1. DALLAS RECREATION CENTER SOLAR ENERGY SYSTEM SCHEMATIC

Mode 3 - Space Cooling: When the COOL AUTO switch on the console switch panel is in the ON position, pump P7 starts if any chilled water valve (V8, V9, or V10) is open to the cooling coil. Pump P6 is interlocked to start when pump P7 is started and the absorption chiller control circuit is enabled. Pump P8 and the cooling tower fan are controlled by the absorption chiller controls. Valve V11 will attempt to maintain generator water temperature at 170°F. The chilled water inventory will be maintained by energizing the chiller when chilled water return temperature exceeds 50°F and by de-energizing the chiller at 44°F. If, during the cooling portion of the cycle, cooling demands cannot be met by the chilled water system and any chilled water valve reaches full open to the coil position, a time delay cycle is initiated which closes chilled water valves V8, V9, and V10 to the coils, and enables the respective air conditioning unit to allow the chilled water storage to recover. During this cycle, pump P7 will be locked on to provide required circulation through the chiller. The time delay cycle is adjustable for up to five hours. After the time delay period, the air conditioning unit is de-energized and the solar mode re-entered.

Mode 4 - Excess Heat Rejection: The hot water storage is provided with two alarm thermostats. One initiates an alarm at the central control console when the storage temperature reaches a selected low level. The other thermostat initiates an alarm if the hot water storage temperature reaches a selected high level. At the same time, valve V1 will be positioned to divert collector solution through heat rejector HX4, where excess energy is dissipated to the outside air.

Mode 5 - Domestic Hot Water: Domestic hot water (DHW) is preheated by heat exchanger HX3 when the cooling tower is active. Energy from hot water storage is exchanged at heat exchanger HX2 when pump P3 is on. Pump P9 is on continuously.

II. PERFORMANCE EVALUATION

The system performance evaluations discussed in this section are based primarily on the analysis of the data presented in the attached computer-generated monthly report. This attached report consists of daily site thermal and energy values for each subsystem, plus environmental data.

The performance factors discussed in this report are based upon the definitions contained in NBSIR 76-1137, Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program.

A. Introduction

The solar energy system was turned on in June 1978, and has been operating with the auxiliary heating system since this time. Site data acquisition was started on September 4, 1978.

The solar energy system operated continuously during May. The space cooling load was 33.07 million Btu, of which the solar energy system provided 7.61 million Btu and the auxiliary system provided 25.46 million Btu.

A malfunction in the automatic controls for the domestic hot water subsystem resulted in fossil energy being transferred to the hot water storage, which is the reverse of the design plan. Natural gas was turned off to the boiler on April 27, 1979. The natural gas was turned off to eliminate the inadvertent transfer of boiler heated water to the hot water storage due to leakage past three-way valves V4 and V5.

B. Weather

The climatological measured versus long-term values are shown below:

	Long-Term Average	Measured
Ambient Temperature (°F)	72.5	71
Heating Degree-Days (°F-day)	0	28
Cooling Degree-Days (°F-day)	236	221
Insolation (Btu/ft^2-day)	1,810	1,548

C. System Thermal Performance

Collector - Of the 175.1 million Btu of solar energy incident on the collector array during May, only 128.7 million Btu were incident on the array when pump P1 (Figure 1) was operating. The system collected a net energy of 41.8 million Btu, or 23.9 percent of the total insolation incident on the collector array. The operation of pumps P1 and P2 to collect energy required 1.8 million Btu.

Energy loss from the collectors was 3.2 percent of the total energy gained by the collectors. This loss was caused by collector flow occurring when the inlet temperature was greater than the outlet temperature. This condition usually occurred during the last 30 minutes of each day prior to pump P1 turning off. Actual energy lost was 1.32 million Btu. Energy loss from piping between the collectors and heat exchanger HX1 was 7.0 million Btu.

Storage - A total of 31.60 million Btu was extracted from storage during the month. The space heating subsystem received no energy from storage. The domestic hot water subsystem recieved no energy from storage. The space cooling subsystem received 31.6 million Btu from storage. The energy in storage increased by 0.2 million Btu during the month.

The domestic hot water subsystem delivered 0.04 million Btu to storage, which is not a normal mode of operation. A review of the net energy flow in and out of storage is shown below:

Solar energy delivered to storage	34.80	Million Btu
Energy delivered to storage from DHW	0.04	Million Btu
Solar energy recovered from storage	31.60	Million Btu
Excess energy	3.20	Million Btu

	3.20	Million Btu
Stored energy change	0.2	Million Btu
Energy loss from storage	3.0	Million Btu

Storage efficiency was 91.3 percent.

Domestic Hot Water - Hot water consumption for May was 2,316 gallons. Average consumption was 75 gallons each day. During May, the average temperature of hot water delivered was 134°F. The hot water consumed was replaced with cold water at an average temperature of 73°F.

During May, no energy was transferred from hot water storage to the DHW heater. Inadvertently 0.04 million Btu was transferred from the DHW heater to the hot water storage. This anomaly was due to a malfunction of the automatic control system.

Space Heating Load - The space heating subsystem report shows a space heating load of 0.86 million Btu supplied by the boiler as auxiliary thermal energy. The report also shows zero auxiliary fossil fuel consumed by the boiler. Since the natural gas to the boiler was turned off, the 0.86 million Btu is an indication of leakage past three-way valves V4 and V5 when pumps P4 and P5 were on. Until the three-way valves are repaired no meaningful conclusions can be obtained from the space heating subsystem report.

Space Cooling Load - The total measured cooling demand was 33.07 million Btu. Of this total, the solar energy system provided 7.61 million Btu, and the auxiliary system provided 25.46 million Btu. The solar cooling system extracted 31.54 million Btu from the hot water storage and required 5.29 million Btu of operating energy.

The auxiliary system, which consists of two air conditioners, used 10.18 million Btu to produce 25.46 million Btu of cooling. The auxiliary system ran 26 days in May. Total cooling operating energy for May was 12.84 million Btu, of which 7.55 million Btu was used to operate the air-handler fans. The absorption chiller operated 25 days in May. The 31.54 million Btu consumed by the genetator of the chiller produced 14.49 million Btu of cooling. This represents a monthly average COP of 0.35. This low COP is due to the chiller operating at times when the return chill water temperature was within 3°F of the outlet temperature. This is discussed in greater detail in Section II.D.

D. Observations

Automatic Control Problems - The transfer of 0.04 million Btu from the DHW heater to the hot water storage tank is not a normal mode of operation. This is due to the automatic controls not being properly set.

Leaking Three-Way Valve - The adverse effect of water leaking past the three-way valves V4 and V5 was eliminated by turning off the natural gas to the boiler. This prevented boiler heated water from flowing to the storage tank and made possible a performance evaluation of the storage subsystem.

Space Cooling Automatic Controls - The suggested changes which would improve performance are:

1) The absorption chiller control circuit should de-energize the absorption chiller when the chilled water return temperature is less than 44°F. The data from the National Solar Data Network (NSDN) indicate that this control may not be functioning. This control should be checked. When the absorption chiller cycles off, it should remain off for 3 1/2 minutes. For example on May 16, 1979, the chilled water return temperature T551 was approximately 42°F from 1313 to 1428 hours. The absorption chiller appears to have continued functioning during this period.

2) The chilled water tank temperature is being maintained too low. For example, temperature sensor T502 which is located in the top of the chilled water tank registered at 39.9°F at 1450 hours on May 16, 1979. At this time the chilled water return temperature sensor T551 registered 42.6°F. Efficiency would increase if the chilled water tank temperature was increased.

3) The auxiliary air conditioners are energized concurrently with the chilled water pump P7. For example, on May 16, 1979, air conditioners number one and two were energized from 1252 to 1417

hours while the absorption chiller was operating and pump P7 circulated 51 gallons of chilled water each minute. The chilled water return temperature sensor T554 registered an average of 41°F during this period. With chilled water available at a temperature of 41°F, the building cooling load could have been within the capability of the absorption chiller.

E. Energy Savings

The Dallas Recreation Center solar energy system resulted in a negative savings of -0.09 million Btu of natural gas during the month. The negative savings was due to 1) the reverse flow of energy from the DHW tank to the thermal storage tank and also due to leakage past valves V4 and V5 and 2) the cooling load supplied by the absorption chiller required more electricity than would have been required had a conventional air conditioner supplied the load. For example, the operating energy for the chilled water system which includes pumps P6, P7 and P8 used 5.29 million Btu. Assuming a COP of 2.5, this would have produced 13.2 million Btu of cooling from a conventional air conditioner. The total cooling load supplied by the chilled water was 7.6 million Btu.

III. ACTION STATUS

The operation of the absorption chiller was discussed by phone with Frank Marshall on May 24, 1979. In order to operate more efficiently, Frank plans to adjust the absorption chiller controls and install a new condenser high limit switch.

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                  SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

                                  MONTHLY REPORT
                                   SITE SUMMARY

SITE: DALLAS RECREATION CENTER DALLAS,TX.                              SOLAR/2038-79/05
REPORT PERIOD: MAY,1979


SITE/SYSTEM DESCRIPTION:
   THE DALLAS RECREATION CENTER SOLAR ENERGY SYSTEM PROVIDES SPACE
   HEATING, COOLING AND DOMESTIC HOT WATER. THE SYSTEM USES A 35%
   PRESTON II SOLUTION IN THE COLLECTOR HX LOOP.  WATER IS USED AS THE
   ENERGY STORAGE MEDIUM.  HOT WATER FROM THE STORAGE TANK IS DISTRIBUTED
   TO IN-DUCT COILS FOR SPACE HEATING, TO THE GENERATOR LOOP FOR DOMESTIC
   HOT WATER HEATING.

GENERAL SITE DATA:
   INCIDENT SOLAR ENERGY                                          175.107 MILLION BTU
                                                                    47975 BTU/SQ.FT.
   COLLECTED SOLAR ENERGY                                          41.810 MILLION BTU
                                                                    11455 BTU/SQ.FT.
   AVERAGE AMBIENT TEMPERATURE                                         71 DEGREES F
   AVERAGE BUILDING TEMPERATURE                                        75 DEGREES F
   ECSS SOLAR CONVERSION EFFICIENCY                                  0.18
   ECSS OPERATING ENERGY                                            1.791 MILLION BTU
   TOTAL SYSTEM OPERATING ENERGY                                   18.339 MILLION BTU
   TOTAL ENERGY CONSUMED                                           78.055 MILLION BTU

SUBSYSTEM SUMMARY:
                          HOT WATER         HEATING         COOLING         SYSTEM TOTAL
   LOAD                       1.198           0.855          33.067        34.980 MILLION BTU
   SOLAR FRACTION               100              -0              24            25 PERCENT
   SOLAR ENERGY USED         -0.042          -0.015          31.536        30.972 MILLION BTU
   OPERATING ENERGY           0.000           3.708          12.839        18.339 MILLION BTU
   AUX. THERMAL ENERGY        4.624           0.869           7.128         5.503 MILLION BTU
   AUX. ELECTRIC FUEL          N.A.            N.A.          10.183        10.183 MILLION BTU
   AUX. FOSSIL FUEL           7.706           0.000            N.A.         7.706 MILLION BTU
   ELECTRICAL SAVINGS        -0.001            N.A.          -2.244        -4.036 MILLION BTU
   FOSSIL SAVINGS            -0.070          -0.024            N.A.        -0.094 MILLION BTU

SYSTEM PERFORMANCE FACTOR:                    0.341

*   DENOTES UNAVAILABLE DATA
@   DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
           OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978,
           SOLAR/0004-78/18
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                         SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

                                        MONTHLY REPORT
                                         SITE SUMMARY

SITE: DALLAS RECREATION CENTER DALLAS,TX.                                  SOLAR/2038-79/05
REPORT PERIOD: MAY,1979


SITE/SYSTEM DESCRIPTION:
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   PRESTON II SOLUTION IN THE COLLECTOR HX LOOP.  WATER IS USED AS THE
   ENERGY STORAGE MEDIUM.  HOT WATER FROM THE STORAGE TANK IS DISTRIBUTED
   TO IN-DUCT COILS FOR SPACE HEATING, TO THE GENERATOR LOOP FOR DOMESTIC
   HOT WATER HEATING.

GENERAL SITE DATA:
   INCIDENT SOLAR ENERGY                                                  184.738 GIGA JOULES
                                                                           544799 KJ/SQ.M.
   COLLECTED SOLAR ENERGY                                                  44.109 GIGA JOULES
                                                                           130080 KJ/SQ.M.
   AVERAGE AMBIENT TEMPERATURE                                                 22 DEGREES C
   AVERAGE BUILDING TEMPERATURE                                                24 DEGREES C
   ECSS SOLAR CONVERSION EFFICIENCY                                          0.18
   ECSS OPERATING ENERGY                                                    1.890 GIGA JOULES
   TOTAL SYSTEM OPERATING ENERGY                                           19.348 GIGA JOULES
   TOTAL ENERGY CONSUMED                                                   82.348 GIGA JOULES

SUBSYSTEM SUMMARY:
                         HOT WATER          HEATING         COOLING          SYSTEM TOTAL
   LOAD                      1.264            0.902          34.886          36.904 GIGA JOULES
   SOLAR FRACTION              100               -0              24              25 PERCENT
   SOLAR ENERGY USED        -0.044           -0.015          33.270          32.675 GIGA JOULES
   OPERATING ENERGY          0.000            3.912          13.545          19.348 GIGA JOULES
   AUX. THERMAL ENG          4.878            0.917           7.520           5.806 GIGA JOULES
   AUX. ELECTRIC FUEL         N.A.             N.A.          10.743          10.743 GIGA JOULES
   AUX. FOSSIL FUEL          8.130            0.000            N.A.           8.130 GIGA JOULES
   ELECTRICAL SAVINGS       -0.001             N.A.          -2.367          -4.257 GIGA JOULES
   FOSSIL SAVINGS           -0.074           -0.026            N.A.          -0.100 GIGA JOULES

SYSTEM PERFORMANCE FACTOR:                    0.341

*   DENOTES UNAVAILABLE DATA
@   DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
           OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978,
           SOLAR/0004-78/18
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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: DALLAS RECREATION CENTER DALLAS,TX. SOLAR/2038-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	3.583	66	0.393	N	0.032	0.387	0.109
2	2.703	72	0.000	O	0.000	0.000	-0.003
3	0.007	67	0.000	T	0.000	0.000	-0.461
4	1.779	55	0.000		0.000	0.000	0.000
5	8.639	63	0.545	A	0.094	1.179	0.063
6	8.663	69	2.826	P	0.096	1.019	0.326
7	8.351	74	0.881	P	0.092	1.062	0.106
8	6.371	77	0.856	L	0.073	0.604	0.134
9	4.108	77	0.456	I	0.019	0.266	0.111
10	5.011	76	0.669	C	0.057	0.475	0.134
11	0.720	55	0.830	A	0.000	0.000	1.144
12	8.857	59	0.014	B	0.091	1.606	0.000
13	8.384	68	0.472	L	0.085	3.278	0.056
14	8.428	73	0.857	E	0.089	2.642	0.098
15	8.240	75	2.473		0.091	2.267	0.300
16	7.854	76	2.459		0.088	0.745	0.298
17	5.703	76	1.364		0.080	0.264	0.238
18	8.169	77	2.252		0.091	0.664	0.276
19	5.678	78	0.969		0.056	0.394	0.167
20	5.302	78	0.961		0.060	0.350	0.139
21	2.683	72	0.031		0.010	0.099	0.010
22	2.007	65	0.005		0.002	0.227	0.000
23	7.790	74	2.106		0.088	0.826	0.270
24	8.336	68	2.378		0.097	0.395	0.282
25	8.647	68	2.573		0.096	0.857	0.273
26	7.592	73	2.068		0.090	0.550	0.272
27	7.171	79	1.904		0.087	0.566	0.277
28	4.636	76	1.122		0.055	0.506	0.242
29	3.309	68	0.112		0.023	0.119	0.027
30	1.425	69	0.000		0.000	0.000	0.000
31	4.962	79	0.041		0.049	0.517	0.006
SUM	175.107	-	31.615	N.A.	1.791	21.864	-
AVG	5.649	71	1.020	N.A.	0.058	0.705	0.177
NBS ID	0001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: DALLAS RECREATION CENTER DALLAS,TX.　　　SOLAR/2038-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	3.583	2.102	0.736	70	0.206
2	2.703	0.000	0.000	76	0.000
3	0.007	0.000	0.000	68	0.000
4	1.779	0.000	0.000	56	0.000
5	8.639	7.270	2.339	72	0.271
6	8.663	7.325	2.378	78	0.274
7	8.351	7.068	2.190	81	0.262
8	6.371	5.018	0.812	83	0.127
9	4.108	1.429	0.119	81	0.029
10	5.011	3.710	0.968	96	0.193
11	0.720	0.000	0.000	54	0.000
12	8.957	7.503	2.367	70	0.267
13	8.384	7.090	2.669	82	0.318
14	8.428	7.257	2.382	83	0.283
15	8.240	7.067	2.090	96	0.254
16	7.854	6.503	2.509	86	0.319
17	5.703	4.313	1.182	83	0.207
18	8.169	6.806	2.410	*	0.295
19	5.678	3.553	1.232	*	0.217
20	5.302	3.465	1.181	83	0.223
21	2.683	0.694	0.159	75	0.059
22	2.007	0.238	0.201	69	0.100
23	7.790	6.518	2.460	82	0.316
24	8.336	7.100	2.370	73	0.284
25	8.647	7.271	2.491	75	0.288
26	7.592	6.137	2.106	81	0.277
27	7.171	5.863	1.952	96	0.272
28	4.636	3.538	1.495	87	0.323
29	3.309	1.446	0.108	*	0.033
30	1.425	0.000	0.000	69	0.000
31	4.962	2.377	0.903	83	0.182
SUM	175.107	128.662	41.810	-	-
AVG	5.649	4.150	1.349	77	0.239
NBSID	0001		0100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: DALLAS RECREATION CENTER DALLAS,TX. SOLAR/2038-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.539	0.393	0.009	157	0.746
2	0.009	0.000	-0.187	155	-20.334
3	0.003	0.000	-0.172	151	-53.525
4	0.000	0.000	-0.250	146	1.000
5	2.323	0.545	1.626	167	0.935
6	2.298	2.826	-0.945	168	0.819
7	2.132	0.881	1.371	175	1.056
8	0.830	0.856	-0.049	186	0.972
9	0.000	0.456	-0.602	180	1.000
10	0.921	0.669	0.216	175	0.962
11	0.006	0.830	-1.108	163	-46.783
12	1.975	0.014	1.821	175	0.929
13	0.566	0.472	-0.125	195	0.613
14	0.949	0.857	0.183	192	1.097
15	0.807	2.473	-1.810	184	0.823
16	2.362	2.459	-0.009	161	1.037
17	1.175	1.364	-0.019	157	1.145
18	2.413	2.252	0.031	159	0.946
19	1.179	0.969	-0.009	157	0.814
20	1.017	0.961	0.025	157	0.970
21	0.153	0.031	-0.109	155	-0.516
22	0.000	0.005	-0.081	154	1.000
23	2.289	2.106	0.187	158	1.002
24	2.403	2.378	0.012	160	0.994
25	2.520	2.573	-0.025	152	1.012
26	2.080	2.068	0.016	159	1.002
27	1.925	1.904	-0.009	160	0.984
28	1.169	1.122	0.031	158	0.986
29	0.281	0.112	-0.034	157	0.275
30	0.000	0.000	-0.199	154	1.000
31	0.511	0.041	0.385	156	0.833
SUM	34.833	31.615	0.171	-	-
AVG	1.124	1.020	0.006	164	0.913
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: DALLAS RECREATION CENTER DALLAS,TX.
REPORT PERIOD: MAY,1979

SOLAR/2038-79/05

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.044	100	0.000	0.000	0.158	N	0.263	0.000	0.000	67	136	80
2	0.050	100	-0.009	0.000	0.139	O	0.231	-0.000	-0.015	70	134	93
3	0.036	100	-0.003	0.000	0.150	T	0.249	-0.000	-0.005	70	133	68
4	0.035	100	0.000	0.000	0.111		0.184	0.000	0.000	69	134	63
5	0.025	100	0.000	0.000	0.113	A	0.188	0.000	0.000	68	136	43
6	0.006	100	0.000	0.000	0.113	P	0.189	0.000	0.000	68	133	11
7	0.050	100	0.000	0.000	0.159	P	0.264	0.000	0.000	70	134	92
8	0.055	100	0.000	0.000	0.134	L	0.223	0.000	0.000	71	135	103
9	0.039	100	0.000	0.000	0.202	I	0.336	0.000	0.000	72	133	77
10	0.058	100	0.000	0.000	0.143	C	0.238	0.000	0.000	73	134	115
11	0.070	100	-0.006	0.000	0.149	A	0.249	-0.000	-0.010	71	135	133
12	0.005	100	0.000	0.000	0.107	B	0.179	0.000	0.000	70	134	10
13	0.005	100	0.000	0.000	0.158	L	0.263	0.000	0.000	69	133	9
14	0.059	100	0.000	0.000	0.147	E	0.245	0.000	0.000	71	134	110
15	0.055	100	0.000	0.000	0.129		0.215	0.000	0.000	71	134	105
16	0.060	100	-0.001	0.000	0.164		0.274	-0.000	-0.002	72	134	116
17	0.066	100	0.000	0.000	0.205		0.341	0.000	0.000	73	134	128
18	0.048	100	0.000	0.000	0.150		0.250	0.000	0.000	74	134	96
19	0.009	100	0.000	0.000	0.121		0.201	0.000	0.000	74	132	18
20	0.005	100	0.000	0.000	0.126		0.209	0.000	0.000	74	132	11
21	0.063	100	0.000	0.000	0.134		0.223	0.000	0.000	75	134	127
22	0.052	100	0.000	0.000	0.241		0.402	0.000	0.000	74	134	102
23	0.063	100	0.000	0.000	0.156		0.261	0.000	0.000	74	134	124
24	0.032	100	-0.023	0.000	0.144		0.239	-0.000	-0.038	74	133	64
25	0.052	100	0.000	0.000	0.203		0.338	0.000	0.000	75	133	102
26	0.007	100	0.000	0.000	0.123		0.206	0.000	0.000	79	133	14
27	0.000	100	0.000	0.000	0.128		0.213	0.000	0.000	80	131	1
28	0.000	100	0.000	0.000	0.133		0.222	0.000	0.000	76	130	0
29	0.047	100	0.000	0.000	0.160		0.266	0.000	0.000	75	134	94
30	0.047	100	0.000	0.000	0.160		0.266	0.000	0.000	76	134	96
31	0.056	100	0.000	0.000	0.166		0.277	0.000	0.000	78	134	114
SUM	1.198	-	-0.042	0.000	4.624	N.A.	7.706	-0.001	-0.070	-	-	2316
AVG	0.039	100	-0.001	0.000	0.149	N.A.	0.249	-0.000	-0.002	73	134	75
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: DALLAS RECREATION CENTER DALLAS, TX.
REPORT PERIOD: MAY, 1979

SOLAR/2038-79/05

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR. OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.002	0	0.000	0.030	0.002	N	0.000	N	0.000	72	66
2	0.018	0	0.000	0.149	0.018	O	0.000	O	0.000	75	72
3	0.033	0	0.000	0.220	0.033	T	0.000	T	0.000	76	67
4	0.153	0	0.000	0.560	0.153		0.000		0.000	71	55
5	0.099	0	0.000	0.440	0.099	A	0.000	A	0.000	71	63
6	0.000	0	0.000	0.106	0.000	P	0.000	P	0.000	73	69
7	0.001	0	0.000	0.032	0.001	P	0.000	P	0.000	74	74
8	0.006	0	0.000	0.111	0.006	L	0.000	L	0.000	75	77
9	0.015	0	0.000	0.081	0.015	I	0.000	I	0.000	75	77
10	0.000	0	0.000	0.074	0.000	C	0.000	C	0.000	76	76
11	0.151	0	0.000	0.618	0.151	A	0.000	A	0.000	72	55
12	0.274	0	0.000	0.716	0.274	B	0.000	B	0.000	72	59
13	0.100	-1	-0.015	0.409	0.115	L	0.000	L	-0.024	73	68
14	0.002	0	0.000	0.100	0.002	E	0.000	E	0.000	76	73
15	0.000	0	0.000	0.062	0.000		0.000		0.000	76	75
16	0.000	0	0.000	0.000	0.000		0.000		0.000	76	76
17	0.000	0	0.000	0.000	0.000		0.000		0.000	76	76
18	0.000	0	0.000	0.000	0.000		0.000		0.000	76	77
19	0.000	0	0.000	0.000	0.000		0.000		0.000	76	78
20	0.000	0	0.000	0.000	0.000		0.000		0.000	77	78
21	0.000	0	0.000	0.000	0.000		0.000		0.000	76	72
22	0.000	0	0.000	0.000	0.000		0.000		0.000	76	66
23	0.000	0	0.000	0.000	0.000		0.000		0.000	76	74
24	0.000	0	0.000	0.000	0.000		0.000		0.000	75	68
25	0.000	0	0.000	0.000	0.000		0.000		0.000	75	68
26	0.000	0	0.000	0.000	0.000		0.000		0.000	76	73
27	0.000	0	0.000	0.000	0.000		0.000		0.000	79	79
28	0.000	0	0.000	0.000	0.000		0.000		0.000	80	76
29	0.000	0	0.000	0.000	0.000		0.000		0.000	77	68
30	0.000	0	0.000	0.000	0.000		0.000		0.000	76	69
31	0.000	0	0.000	0.000	0.000		0.000		0.000	76	79
SUM	0.855	-	-0.015	3.703	0.869	N.A.	0.000	N.A.	-0.024	-	-
AVG	0.028	-0	-0.000	0.120	0.028	N.A.	0.000	N.A.	-0.001	75	71
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE COOLING SUBSYSTEM

SOLAR/2038-79/05

SITE: DALLAS RECREATION CENTER DALLAS,TX.
REPORT PERIOD: MAY,1979

DAY OF MON.	SPACE COOLING LOAD MILLION BTU	SOLAR FR. OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG DRY BULB TEMP F	AMB TEMP DEG F
1	0.787	13	0.391	0.137	0.191	0.273	N	-0.020	N	72	66
2	0.150	0	0.000	0.000	0.042	0.060	O	0.000	O	75	72
3	0.495	0	0.000	0.000	0.139	0.198	T	0.000	T	76	67
4	0.046	0	0.000	0.000	0.013	0.018		0.000		71	55
5	0.006	100	0.545	0.040	0.000	0.000	A	-0.038	A	71	63
6	0.169	120	2.326	0.665	0.000	0.000	P	-0.296	P	73	69
7	1.208	23	0.881	0.567	0.263	0.375	P	-0.078	P	74	74
8	2.011	11	0.856	0.905	0.506	0.723	L	-0.240	L	75	77
9	1.822	-2	0.456	0.962	0.520	0.743	I	-0.336	I	75	77
10	1.945	-1	0.669	0.959	0.559	0.798	C	-0.343	C	76	76
11	-0.046	0	0.330	0.492	0.000	0.000	A	-0.193	A	72	55
12	0.000	0	0.000	0.000	0.000	0.000	B	0.000	B	72	59
13	0.065	103	0.487	0.395	0.000	0.000	L	-0.098	L	73	68
14	0.907	13	0.357	0.919	0.227	0.324	E	-0.267	E	76	73
15	1.851	32	2.473	1.073	0.364	0.519		-0.221		76	75
16	1.953	49	2.459	0.693	0.280	0.401		0.066		76	76
17	1.912	41	1.360	0.421	0.317	0.454		0.118		76	76
18	1.941	39	2.252	0.608	0.333	0.476		0.014		76	77
19	1.779	24	0.949	0.311	0.378	0.540		0.023		76	78
20	1.524	33	0.955	0.364	0.288	0.411		0.023		77	78
21	1.897	2	0.026	0.007	0.523	0.747		0.008		76	72
22	0.975	0	0.000	0.000	0.273	0.390		0.000		76	66
23	1.539	55	2.106	0.584	0.192	0.275		0.067		76	74
24	0.701	64	2.378	0.565	0.070	0.100		-0.074		75	68
25	0.766	76	2.573	0.607	0.052	0.074		-0.027		75	68
26	0.752	76	2.066	0.522	0.051	0.073		-0.018		76	73
27	0.530	45	1.903	0.609	0.081	0.116		-0.176		79	79
28	0.499	20	1.120	0.392	0.112	0.159		-0.136		80	76
29	1.464	1	0.091	0.032	0.404	0.577		-0.007		77	68
30	1.270	0	0.000	0.000	0.356	0.508		0.000		76	69
31	2.149	1	0.030	0.008	0.595	0.851		0.005		76	79
SUM	33.067	-	71.536	12.839	7.128	10.183	N.A.	-2.244	N.A.	-	-
AVG	1.067	24	1.017	0.414	0.229	0.328	N.A.	-0.072	N.A.	75	71
NBS	Q502	N500	Q500	Q503	Q501		Q508	Q512	Q514	N406	N113

* DENOTES UNAVAILABLE DATA.
? DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: DALLAS RECREATION CENTER DALLAS,TX. SOLAR/2038-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	982	N	66	70	N	N	N
2	741	O	72	76	O	O	O
3	2	T	67	68	T	T	T
4	487		55	56			
5	2367	A	63	72	A	A	A
6	2372	P	69	78	P	P	P
7	2288	P	74	81	P	P	P
8	1745	L	77	83	L	L	L
9	1125	I	77	81	I	I	I
10	1373	C	76	86	C	C	C
11	197	A	55	54	A	A	A
12	2427	B	59	70	B	B	B
13	2297	L	68	82	L	L	L
14	2309	E	73	83	E	E	E
15	2258		75	86			
16	2152		76	86			
17	1562		76	83			
18	2238		77	*			
19	1556		78	*			
20	1453		78	83			
21	735		72	75			
22	550		66	69			
23	2134		74	82			
24	2284		68	73			
25	2369		68	75			
26	2080		73	81			
27	1965		79	86			
28	1270		76	87			
29	907		68	*			
30	391		69	69			
31	1359		79	83			
SUM	47975	N.A.	-	-	-	-	-
AVG	1548	N.A.	71	77	N.A.	N.A.	N.A.
NBS ID	0001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
THERMODYNAMIC CONVERSION EQUIPMENT

SITE: DALLAS RECREATION CENTER DALLAS,TX. SOLAR/2038-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	EQUIPMENT LOAD MILLION BTU	THERMAL ENERGY INPUT MILLION BTU	OPERATING ENERGY MILLION BTU	ENERGY REJECTED MILLION BTU	COEFFICIENT OF PERFORMANCE (SEE NOTE)
1	0.213	0.391	0.061	0.601	0.544
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000
5	0.156	0.545	0.040	0.704	0.286
6	0.662	2.826	0.363	3.302	0.234
7	0.276	0.881	0.186	0.851	0.313
8	0.588	0.856	0.321	1.049	0.687
9	0.556	0.456	0.322	0.780	1.220
10	0.544	0.669	0.322	1.013	0.814
11	0.455	0.830	0.175	1.135	0.549
12	0.000	0.000	0.000	0.000	0.000
13	0.237	0.487	0.124	0.509	0.487
14	0.472	0.857	0.306	0.905	0.550
15	1.550	2.473	0.442	3.862	0.627
16	1.119	2.459	0.314	3.372	0.455
17	0.812	1.360	0.194	1.983	0.597
18	1.111	2.252	0.287	3.363	0.493
19	0.530	0.949	0.149	1.438	0.559
20	0.650	0.955	0.175	1.220	0.681
21	-0.001	0.026	0.004	0.018	-0.027
22	0.000	0.000	0.000	0.000	0.000
23	1.164	2.106	0.274	3.276	0.553
24	0.773	2.378	0.254	3.110	0.325
25	0.871	2.573	0.260	3.049	0.338
26	0.790	2.066	0.246	2.816	0.382
27	0.569	1.903	0.272	2.416	0.299
28	0.357	1.120	0.176	1.425	0.319
29	0.033	0.091	0.015	0.112	0.362
30	0.000	0.000	0.000	0.000	0.000
31	0.002	0.030	0.004	0.023	0.081
SUM	14.489	31.536	5.287	42.330	0.459
AVG	0.467	1.017	0.171	1.365	0.015

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.
NOTE: $\text{Coefficient of Performance} = \dfrac{\text{Equipment Load}}{\text{Thermal Energy Input}}$

*U.S. GOVERNMENT PRINTING OFFICE: 1979-640-189/4102. Region 4.

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